

## **The lack of physics teachers: “Like a bath with the plug out and the tap half on”**

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### **Abstract**

*In this study, we were interested in how approaches to teaching high school physics in New Zealand influenced students' perceptions of physics and their consequent desire to continue with Physics. We also investigated the reasons participants became physics teachers to inform how more teachers might be attracted into the profession. The convergent parallel design of this study used mixed methods including a national survey as well as classroom observations and interviews with teachers and students. The study has identified how a focus on content knowledge and more “traditional” teaching approaches tends to discourage students to progress with physics.*

**Keywords:** Classroom practices; teaching strategies; physics teachers; physics students

### **Introduction**

There is a global concern about the number of students pursuing physics at both secondary and tertiary levels and the number of graduates wanting to be trained as physics teachers (Institute of Physics [IOP], 2010; PhysTEC, 2014). In 2013, the National Task Force on Teacher Education reported that “the need for qualified physics teachers is greater now than at any previous time in U.S. history.” (PhysTEC, 2014). The decline in interest in the subject has led to the closure of some physics departments at universities (Blickenstaff, 2010). This decline in the numbers of students taking physics could be due to a combination of factors including the perception that physics is a ‘hard’ subject with low achievement of students in physics; the perceived nature of the subject; and how the subject is taught at the high school level. We therefore investigated this as part of the study.

In 1996, in the USA, the National Research Council’s National Science Education Standards put forward five assumptions about science teaching, including the belief that, “What students learn is greatly influenced by how they are taught” (National Research Council, 1996, p. 28). Moreover, in the same year the standards called for a pedagogical shift from a teacher-centered to a student-centered instructional paradigm. It was held that a more student-centered approach to learning engages students in socially interactive scientific inquiry and facilitates lifelong learning. Also, there is considerable evidence to suggest that a move towards pedagogies involving full interaction, collective reflection and the development of consensual knowledge would lead to improved learning and attainment (Conner, 2014; Darling-Hammond & Baratz-Snowden, 2005; Moraru, Stoica, & Popescu, 2011; Smart & Marshall, 2012).

Researchers over the years have maintained that teachers form a strong causal factor in defining the quality of education in schools (Archibald, 2006; Darling-Hammond & Baratz-Snowden, 2005; Golla, de Guzman, Ogena, & Brawner, 1998; Hake, 1998). Teachers see to it

that students have acquired creative and critical thinking abilities ready to face the realities of life. Central to acquiring creative and critical thinking abilities is the ability of teachers to design teaching sequences that develop among the students the abilities to respond to situations that beset them in aspects that make their learning meaningful (Darling-Hammond & Baratz-Snowden, 2005). This suggests that teacher's abilities to create an enabling atmosphere that allows meaningful classroom interaction with students is very important. More so, the types of classroom interactions created by the teacher and the types of questions he/she uses to structure the teaching skills play an important role in the kinds of thinking skills learners employ, the range of information to be covered and the thinking skills they may learn (Darling-Hammond & Baratz-Snowden, 2005; Smart & Marshall, 2012).

Likewise, at the heart of physics education research is a shift in physics instruction from concentrating on teaching to focussing on students' learning. In order to make this shift achievable, Redish and Steinberg (1999) stressed that teachers of physics need to listen to students and find ways to help students learn physics through making their courses meaningful. McDermott (2001) extols that the focus of physics teaching must be on the students as learners. She emphasises that effective teaching includes close contact with students where teachers observe the struggles of students as they try to understand important concepts and principles. Further, McDermott's research indicates that different instructional strategies have different effects on students' learning (McDermott, 2001). What teachers need to understand is that conceptual learning of physics often uses models, animations and simulations for problem solving approaches – Physics by Inquiry (Afra, Osta, & Zoubair, 2009; Akerson, Hanson, & Cullen, 2007; Campbell, Danhui, & Neilson, 2011). The advances in computer hardware and software programs have provided new platforms for instigating conceptual change and problem solving which physics teachers should tap into it (Dünser, Walker, Horner, & Bentall, 2012; Ülen & Gerlič, 2012; Wieman, Perkins, & Adams, 2008). These platforms, for example *Applet*, *PhET* and *BuildAR* provide opportunity for students to interact with the virtual world by changing conditions and immediately observing the results.

Again students are actively engaged which leads to improved learning and belief about physics.

Generally, teachers' beliefs about teaching have potential influence on their teaching practice (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). What people know and believe influences their sense of making and informs the choices they make everyday. In particular, the approaches used by physics teachers to teach physics are generally linked to their views or beliefs about physics as a body of knowledge (Koballa, Glynn, & Upson, 2005; McDermott & Shaffer, 2000). Koballa et al. (2005) argued that teachers' beliefs about teaching are most often reflected in their practice and thus influence their instructional decision-making. McDermott and Shaffer (2000) and Blanton (2003) also observed that teachers of science often teach in the way they have been taught. If they were taught through lectures, they are likely to lecture, even if this type of instruction is inappropriate for their students. Again, Ladachart (2011) found that physics teachers had developed conceptions about teaching based on their previous experiences at school, both as students and as pre-service teachers.

Mulhall and Gunstone (2008, 2012) used qualitative methodology to explore views about physics held by a group of physics teachers whose teaching practice was traditional, and

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compared these with the views held by physics teachers who used conceptual change approaches. Through semi-structured interviews and observations, Mulhall and Gunstone (2008, p. 444) discussed that:

*The Traditional teachers thought of physics learning as the outcome of doing certain activities, and in terms of acquisition of information about physics ideas. For the traditional teachers, physics was seen as hard because it is mathematical and abstract, and many learners do not have the special attributes necessary to learn it. The conceptual teachers thought that learning involves cognitive activity by the learner, and that individuals construct their own understanding in terms of their personal frameworks. For the conceptual teachers, the ideas of physics were considered to be counter-intuitive and troublesome in terms of learning. They saw discussion as being important for learners as it helps tease out and develop understandings of physics ideas. (Mulhall & Gunstone, 2012, p. 444)*

#### Previous Research - Nature of Physics Classroom Practices

Even though many empirical studies have demonstrated that carefully planned, interactive instruction can be effective in promoting conceptual change and enhance performance (Cahyadi, 2007; McDermott & Redish, 1999; Redish & Steinberg, 1999; Thacker, 2003; Vosniadou, 2007; Wieman et al., 2008), findings from the literature show that many physics teachers continue to teach using the same old, ineffective, traditional, teacher-centred instructional approach (Angell, Guttersrud, Henriksen, & Isnes, 2004; Gallagher, 1991; Hackling, Goodrum, & Rennie, 2001; Tobin & Gallagher, 1987; Vosniadou, 2007).

For instance in the late eighty's in Perth Australia, Tobin and Gallagher (1987) found that the common instructional mode in high school science classes was whole class interactive – when the teacher dealt with the class as a whole, and interacted with one student at a time while the others listened; and whole class non-interactive – comprised of lecture presentations followed by individual seatwork and small group activities. More than a decade after, Hackling et al. (2001) found that the teacher-centred instructional approach was still prevalent in many of the secondary schools in Australia:

For many secondary students, the teaching-learning process is teacher directed and lessons are of two main types: practical activities where students follow the directions of the teacher to complete an experiment, and the chalk and talk lesson in which learning is centred on teacher explanation, copying notes and working from an expository text. (Hackling et al., 2001, p. 8)

In Hackling et al's study, the extent of teacher-centredness was reported by 61% of secondary students who indicated that they copied notes from the teacher nearly every lesson. As well, 59% of students indicated that the teacher never allowed them to choose their own topics to investigate.

A similar situation was described in high schools in Norway. Angell et al. (2004) administered questionnaires to 2192 students taking physics and 342 physics teachers in high schools in Norway, followed by interviews. They found that proportionally a greater part of classroom time (about 60%), in relation to physics, was spent with the teacher presenting new material on the blackboard/whiteboard. Physics classrooms were dominated by "chalk and talk instruction" (p. 701). Though students in the study perceived physics as interesting and related to everyday phenomena, they also perceived the subject as difficult/demanding,

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formalistic in nature and more mathematical. The majority of the students wanted stronger emphasis on context and connectedness as well as qualitative/conceptual approaches and more student-centred approaches. Based on the findings, the authors suggested that:

“...secondary physics education preparing students for tomorrow’s society should be characterized by variety, both within and among courses, integration of mathematics in the physics courses, more pupil-centred instruction, and a stronger emphasis on knowledge in context. (p. 703)

It has also been shown that interactions affect learners' attitude towards learning and their participation in class activities (Masika, 2011). Masika indicated that teacher interaction behaviours were an important aspect of the learning environment and were strongly related to high school student outcomes. Masika found that, in Kenya, physics teachers were autocratic and dominated their classrooms by talking only and sometimes talking with illustrations. One can infer from the above studies that teacher-centred instruction continues to be a widely used instructional strategy in secondary school physics classrooms. Moreover, students have expressed a desire for more interactive environments. If traditional approaches to teaching physics, which often fail to promote adequate student understanding of physics concepts, still persist (Angell et al., 2004; Hackling et al., 2001; Masika, 2011; Mulhall & Gunstone, 2008, 2012) then there is a huge challenge to promote pedagogical change so that physics teachers teach for better student learning.

### Context of this Study

Science is one of the eight learning areas that the *New Zealand Curriculum (NZC)* specifies as important for a broad, general education for every child (Ministry of Education, 2007). In the science learning area, students are expected to explore both how natural physical world and science itself work so that they can participate as “critical, informed and responsible citizens in a society in which science plays a significant role” (Ministry of Education, 2007, p. 17). In addition, the *NZC* describes five key competencies as directions for learning – thinking; communication (using language, symbols and text); managing self; relating to others; and participation and contributing which align with the 21<sup>st</sup> century learning skills - integration of information technology, and developing children’s skills in collaboration, communication, critical thinking and creative problem solving (Conner, 2013b).

The 2007 *New Zealand Curriculum (NZC)* defines effective pedagogy as “teacher actions that promote student learning” (Ministry of Education, 2007, p. 34). The NZ education context requires schools to design their own learning programmes to meet the needs of their communities and students (Education Review Office, 2012; Ministry of Education, 2007). The *NZC* emphasises the importance of creating and encouraging reflective thought and action; enhancing relevance; facilitating shared learning; making connections to prior learning and experience; providing sufficient opportunities to learn; and inquiring into teaching and learning relationship. All these are key elements of inquiry-based learning. Thus, when students are taught by inquiry, individuals are actively engaged with others in attempting to understand and interpret phenomena for themselves thereby improving performance. Our study used mixed methods to answer the following questions:

1. Why did teachers become physics teachers?
2. How do approaches to teaching and learning affect students’ perceptions of physics?

3. What changes do secondary teachers and students perceive need to occur to make physics more interesting to learn?
4. What were students saying about why they would or would not become physics teachers?

### Theoretical Framework

The study was underpinned by the constructivist theory. Constructivism is characterized by the view that knowledge is not transmitted directly from one person to another, but is actively built up by the learner (Cobern, 1998; Driver, Asoko, Leach, Scott, & Mortimer, 1994). Conner (2014) also accentuates that a constructivist classroom is a learner-centred environment which acknowledges and brings to the fore the past experience of students. She articulates that in constructivist classrooms, learning is “reflective, interactive, inductive and collaborative, and questions are valued as a source for curiosity and focus for finding out information” (p. 3). Constructivism as a theory, has evolved from not only learning about declarative knowledge (knowing what) but also knowing “how and when” to learn in different ways (Conner, 2014). In such classrooms, accordingly, the teacher acts as a facilitator or mediator of learning rather than someone who only takes on the role of imparting knowledge.

### Methodology

#### Design

Mixed methods were used and included a national survey of 104 physics teachers throughout New Zealand and interviews with 82 physics high school students. Specifically, the *convergent parallel design* (Creswell & Clark, 2011) was employed for this study. The teachers’ survey identified their current views of classroom practices, perceptions about what limits the quality of physics teaching and learning, and how teaching and learning of physics can be improved. The students’ survey gathered students’ views about their experiences in physics classrooms, their competencies and challenges, and what would motivate them to learn physics and possibly to become physics teachers. Focus group interviews with physics students and individual physics teachers provided supplementary data.

If a study uses different research methods for example quantitative and qualitative, it has the advantage of helping the researcher to get a deeper understanding of certain issues pertaining to the problem under investigation (Best & Kahn, 2005; Cohen, Manion, & Morrison, 2007; Taylor, 2004). Again, as Gray (2009) noted, “people may articulate a particular view, but in practice behave differently” (p. 221). Triangulation and comparison of data from multiple sources therefore lead to trustworthiness and to the credibility of interpretation (Bogdan & Biklen, 2007; Cohen et al., 2007; Keser, Akdeniz, & Yyu, 2010; Sarantakos, 2005; Yin, 2009). Likewise, it enables researchers to delve deeper into issues that might not be possible to obtain from questionnaires alone (Fraenkel, Wallen, & Hyun, 2012).

#### Instruments and Procedure

An online survey questionnaire and semi-structured interview protocols were developed for the study. Two forms of both closed and open-ended questionnaires were developed and used for data collection. These were the Physics Teachers’ Questionnaire (PTQ) and Physics Students’ Questionnaire (PSQ). Both the PTQ and PSQ were adapted from existing surveys

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for evaluating secondary schools science and mathematics classrooms (Angell et al., 2004; Hackling et al., 2001; Weiss, Banilower, McMahon, & Smith, 2001). The questionnaire asked both Physics teachers and students to indicate on a five-point Likert scale (with extreme alternatives of Always – Never) how often a number of teaching strategies and practices occur in their physics classrooms. Students were also asked to indicate how often they would like these strategies and practices to be applied. The practices were grouped under the following subheadings: teaching approaches, teacher feedback and guidance, and ICT usage in physics teaching. We triangulated the findings from the survey with in-depth interviews with four teachers. Focus group interviews with Year 12 and 13 physics students were also conducted. Fourteen focus group interviews were conducted with a total of 82 students. Ethical approval for this study was obtained from the University of Canterbury Human Ethics in Research Committee.

The semi-structured interview protocols for physics teachers and students were designed to gather data in the participants' own words (Fraenkel et al., 2012). As May (2001) noted: "the interviewer can seek both clarification and elaboration on the answers given and thus enter into a dialogue with the interviewee" (p. 123). The semi-structured method also allows the researcher to raise issues of particular concern to the study (Fraenkel et al., 2012). Further questions, which were not expected at the commencement of the interview, could be also be asked as new issues arose (Gray, 2009).

#### *Data analysis*

Data from teachers and student survey questionnaires were analysed using descriptive and inferential statistical methods, including percentages, means, standard deviations and MANOVA where appropriate. Audio recordings from interviews were listened to several times and transcribed precisely. Nvivo 10 for Windows was used to organize the materials by coding them into nodes which provided easy retrieval of the themes that emerged. Our analysis is given in terms of the data gathered from teachers and students' responses. Where quotes are used, these are representative of the statements of many teachers and students. The production of accurate and verbatim transcript is integral to establishing the credibility and trustworthiness (Lewis-Beck, Bryman, & Liao, 2004).

### **Results**

#### *Why Teachers Became Physics Teachers*

Physics was a first-choice teaching subject for about three quarters of the teachers surveyed. Reasons cited for becoming physics teachers fell into the following categories: personal interest; family background; an encounter with inspiring physics teacher; and access to a teacher scholarship scheme. The summary of their responses are presented in Figure 1.

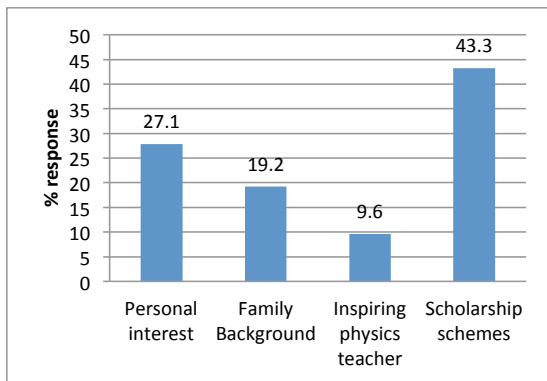


Figure 1: Reasons why teachers became physics teachers

As seen in Figure 1, majority of the teacher (43.3%) became physics teachers through scholarship schemes that were instituted specifically for the training of physics teachers due to a shortage at that time. The financial benefit offered to them to become Physics teachers was greater than previous remuneration. became physics teachers through scholarship schemes that were instituted specifically for the training of physics teachers due to the shortage at that time. The money offered to them to be trained as physics teachers was more than what they were receiving in their previous jobs so they accepted the offer to be trained. One teacher remarked:

*...and at that time they had a scheme to encourage physics graduates into teaching because there was a shortage at that time (1979), and so I was offered more money to train as a teacher than I was getting from my previous job.*

About 27% of the teachers emphasized that they had always wanted to teach, and because they excelled at physics and mathematics and/or did a physics related course at university, they became physics teachers. Only a few of them (about 10%) remarked that their previous physics teachers were influential in their decisions to become physics teachers. They attributed it to the kind of inspiring physics teachers who taught them physics in the course of their studies. For the reasons outlined above the teachers decided to pursue physics studies at either Teacher's College or completed 1-year post graduate diploma in Physics Education in Faculties of Education in universities and/or had participated in a conjoint degree programme (e.g. Bachelor of Teaching or post graduate Bachelor of Secondary teaching) to become physics teachers.

As can be seen in Figure 2, about one quarter of the teachers had switched to physics from another subject in the course of their teaching career. Their reasons for doing so were explored and fell into one of three categories: lack of physics teachers/subject specialist; job availability; and interest in the subject.

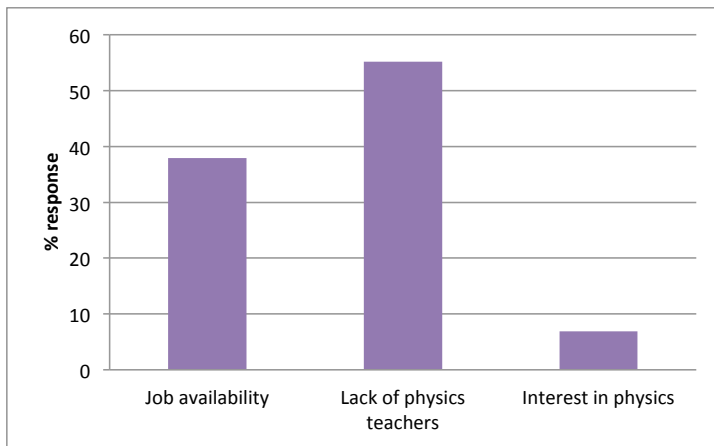


Figure 2: Teachers' reasons for switching to physics

The main reason why the teachers changed to physics was lack of physics teachers/subject specialist to teach the subject in the various schools as majority of the teachers (about 55 %) stated this as the major reason. Job availability was the next most popular reason mentioned by about 40% of the teachers.

#### Approaches to Teaching and Learning of Physics

In order to find out what happens in the physics classroom and what effect this has on students' perceptions of physics, both physics teachers and students were asked to indicate on a five-point Likert scale (with extreme alternatives of Always – Never) about how often a teaching strategies and practices occur in their physics classrooms. Students were also asked to indicate how often they would like these strategies and practices to be applied. The practices were grouped under the following sub-headings: teaching approaches; teacher feedback and guidance; and ICT usage in physics teaching. Both responses were coded and ranked on a five-point Likert scale format with 'Never'=1; 'Not Often'=2; 'Sometimes'=3; 'Most of the Time'=4; and 'Always'=5. The findings of the physics teacher's responses to the rating-scale items are reported in Table 1, Table 2 and Table 3 respectively. The findings from the students' responses are presented in Figures 3, 4 and 5.

As can be seen in Table 1, the teachers responded to many points about what actually takes place in the physics classroom regarding their teaching methods. The overall mean score and standard deviation on this sub-scale were:  $M = 3.39$  and  $SD = 0.76$ . This gives an indication that physics teachers 'sometimes' use the named teaching strategies. An examination of the individual items shows that teachers most of the time use the white board for classroom proceedings ( $M = 3.89$ ,  $SD = 0.75$ ). Teachers also seemed to use of demonstration and discussion to illustrate concept/phenomena most of the time ( $M = 3.86$ ,  $SD = 0.73$ ). Teacher-centred approaches were prevalent in most physics classrooms ( $M = 3.73$ ,  $SD = 0.86$ ). Students' ideas and suggestions were not often used in teaching ( $M = 2.79$ ,  $SD = 0.63$ ). In addition, students were seldom given opportunities to plan and carry out their

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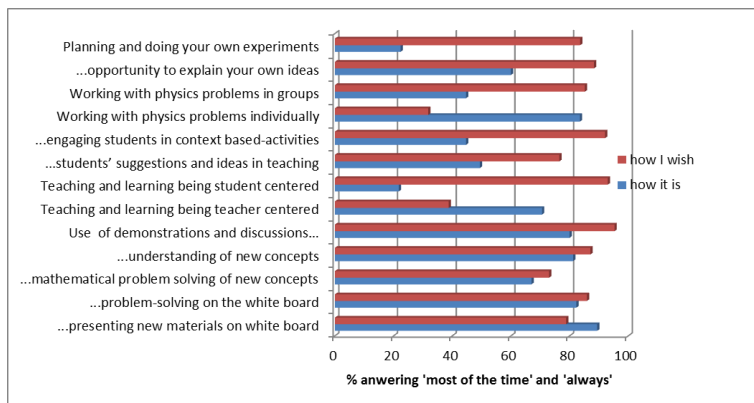


own experiments ( $M = 2.55$ ,  $SD = 0.85$ ) as most often they would perform experiments by following teachers' instructions.

*Table 1: Means and Standard Deviation Scores of Items on Teaching Approaches*

Statements	Mean	Std. dev.
I present new materials on white board	3.55	0.88
I demonstrate problem-solving on the white board	3.89	0.75
I lay emphasis on mathematical presentation of concepts	3.53	0.96
I lay emphasis on qualitative thinking and presentation of concepts	3.82	0.81
I use demonstrations and discussions to illustrate concepts/phenomena	3.86	0.73
Teaching and learning is teacher directed	3.73	0.86
Teaching and learning is students' directed	2.79	0.63
I use students suggestions and ideas in teaching	3.28	0.77
I engage students in context based-activities	3.28	0.77
Students work with physics problems individually	3.27	0.67
Students work with physics problems in groups	3.25	0.62
Students have opportunity to explain their own ideas	3.60	0.77
Students do experiment by following instructions from the teacher	3.30	0.75
Students plan and do their own experiment	2.55	0.85
Average scores	3.39	0.76

The findings in Figure 3 show that students generally agreed with the teachers on many points about how often the teaching strategies and practices were applied. For example, students had few opportunities to plan and carry out their own experiments. Teaching and learning was more teacher centred than student centred. An examination of students experience in relation to what actually happened in their classroom (with regards to the teaching approaches) and how often they would prefer the strategies to be applied reveal that students were relatively not satisfied with many of the instructions they received.



*Figure 3: Students' responses of item on teaching approaches*

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Teacher feedback and guidance sub-scale was used to find out how physics teachers relate, encourage, motivate and show interest in their students' learning. The mean scores and standard deviations of the responses are presented in Table 2.

*Table 2: Means and Standard Deviation Scores of Items on Teacher Feedback and Guidance*

Statements	Mean	Std. dev.
Tell students how they can improve their performance	3.94	0.68
Give quizzes that I mark to see how students are performing	2.89	0.80
Talk to students on how they are getting on in physics	3.68	0.80
Mark students' work and give it back quickly	3.97	0.81
Use language that is easy to understand	4.24	0.63
Show students how new concepts in physics relate to what we have already done	4.11	0.76
Average scores	3.81	0.75

The overall mean score and standard deviation for the teachers on teacher feedback and guidance were:  $\bar{M} = 3.81$  and  $SD = 0.75$  respectively. This indicates that teachers in the survey perceived their response and assistance to students to be highly positive. The item "I use language that is easy to understand" ( $\bar{M} = 4.24$ ,  $SD = 0.63$ ) and "show students how new concepts relate to what we have already done" ( $\bar{M} = 4.11$ ,  $SD = 0.76$ ) for example, were rated highly positive. On the other hand, formative types of assessment in classrooms, such as giving quizzes and marking these to see how students are performing rarely occurred ( $\bar{M} = 2.89$ ,  $SD = 0.80$ ). The mean score value was far below the average mean score (3.81) as indicated in Table 2.

Similarly, as indicated in Figure 4, students agreed with the teachers on almost all the items on this sub-scale. The majority of the students (84%) indicated that their teacher's use of language was easy to understand. About 75% also stated that teachers often showed them how new concepts related to what they had done already. On the contrary, the students perceived that teachers did not talk to them about how they were getting on in physics as often as purported by the teachers. It was the wish of the majority (92%) that teachers showed interest in their learning by having discussions with them about their performance in physics. The majority of the students (about 90%) would also like to have formative types of assessment in the classroom to see how they were performing in the subject.

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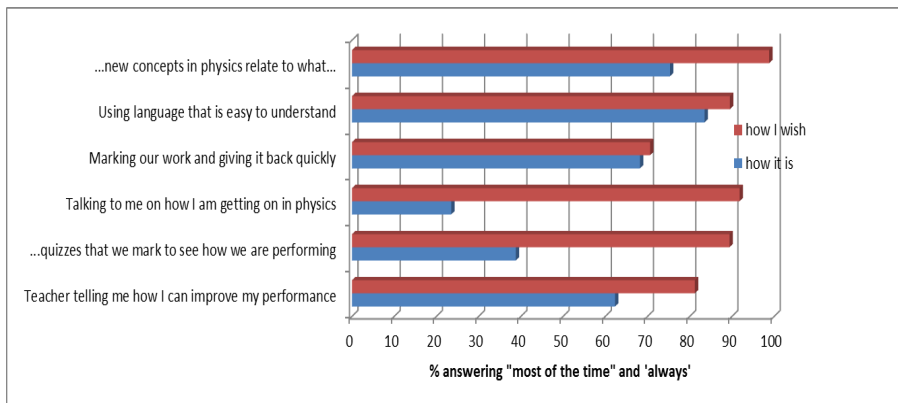


Figure 4: Students responses of items on teacher feedback and guidance

The third sub-scale, ICT usage in physics teaching, was used to find out how often physics teachers use ICT tools to enhance teaching and learning of physics. As shown in Table 3, the mean scores on all five questions related to use of ICT indicated that the majority of physics teachers used ICT tools to facilitate teaching and learning of the subject sporadically or rarely at all.

Table 3: Means and Standard Deviation Scores of Items on ICT Usage in Physics Teaching

Statements	Mean	Std. dev.
Use computers for laboratory simulations	2.83	0.88
We look for information on the internet at school	2.88	0.83
Use computers to collect and/or analyze data	2.50	0.91
Use computers to demonstrate physics principles	2.92	0.68
Students use their phones to search for information at school	2.31	0.98
Average scores	2.67	0.86

Likewise, students in the survey confirmed that ICT tools were rarely used in teaching and learning of physics as shown in Figure 5. Looking at the differences between “how it is” and “how I wish” for the usage of ICT tools, it could said that students were generally not satisfied with the current situation. A change in teaching strategies to involving ICT tools in teaching physics is thus inevitable.

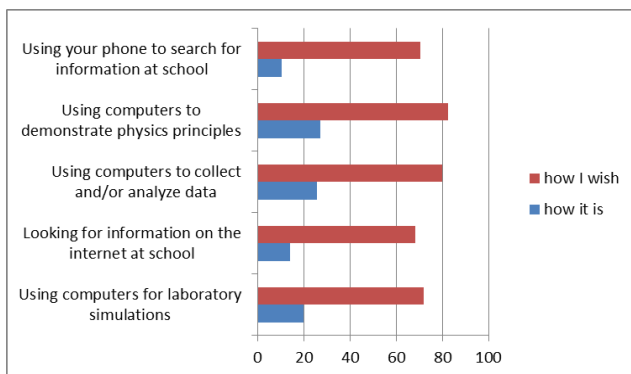


Figure 5: Students responses of items on ICT usage in physics teaching

#### Suggested Changes to Make Physics more interesting to Learn

The teachers who participated in the survey acknowledged that several factors hinder the quality of teaching and learning in physics at high schools and this may contribute to the low numbers involved. Therefore they called for changes and/or improvements to be made. Chief amongst the limiting factors were: assessment demands; curriculum and time tabling; unequal access to physics teaching at junior science; teacher factors and pedagogy; the perceived nature of physics; weak mathematics background; and low salary/lack of incentives for teachers to come into the profession. For instance the teachers bemoaned that the Junior Science does not provide adequate preparation for students to pursue Level 2 (Year 12) and Level 3 (Year 13) physics. They observed that because of the integrated way science is taught at junior level, some students may not meet a physics teacher until Year 12 when they have already formed their misconceptions and made choices. They further indicated that many students do not start to do real science until Year 9 and even then the physics teaching at junior level is poor because the “biology teachers” shy away from it and have little passion for it. One teacher remarked:

*Progression of physics through lower levels being taught by non-physicists is a major problem. Often students come to senior physics with misconceptions from learning physics in junior school by teachers not having adequate physics knowledge.*

The open-ended question which asked teachers to suggest ways for improving the teaching and learning of senior physics and to increase the numbers students involved yielded 98 individual responses. The suggestions for improvement provided by the teachers fell into the following categories shown in Table 4. The most common suggestions for improvement by the teachers included reducing curriculum content and assessment requirement (30.6%); better salary and support for physics teachers (21.4%); having more qualified physics teachers (17.3%) and professional learning on subject matter content knowledge (15.3%); and good physics and mathematics teaching at junior school (15.3%).

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Table 4: Physics Teachers Suggestions for Improving Teaching and Learning of Senior Physics (N = 98)

Category	N	%
Improved salary and support	21	21.4
Curriculum content and assessment requirements	30	30.6
Improved physics and mathematics tuition at junior level	15	15.3
Professional development on content knowledge	15	15.3
More qualified physics teachers	17	17.3

#### *Why Students would or would not Become Physics Teachers*

The students' interviews centered on physics teaching and learning, their interest and achievement in physics and why they would or would not want to become physics teachers. Fourteen focus group interviews were conducted with a total of 82 students. When responding to: "Do you enjoy Physics lessons and what helps you to enjoy or not enjoy Physics lessons?" about three quarters of the students mentioned that they enjoyed physics lessons and found them interesting and fun because the content related to the real world. They also thought that sometimes the lessons were uninspiring, making the subject boring. Some students only enjoyed physics when they understood what was being taught, otherwise they became confused and didn't really like it. Others also indicated that they didn't particularly enjoy physics lessons because the content was too difficult for them.

*I enjoy it if I get it, if I get what is we're doing in class, but if I don't I'm just confused and don't really like it. (Girl, Year 12)*

*If I understand it then I seriously enjoy physics, but if I don't understand anything I think I just shut down and sit there a bit confused. (Boy, Year 13)*

About three-fourths of the students stated that they were unhappy with their performance in physics. Almost everyone cited the difficulty, nature of physics and teaching approaches as the reasons for their poor performance. When asked what makes learning physics difficult, students strongly emphasised that physics is difficult to learn because of the inherent nature of the subject: many concepts, numerous formula (equations), different forms of symbolic representation, and the mathematics was confusing.

*I think it's just all the formulas and the equations because some of them are quite similar so it's just getting the hang of which is which. There's lot of concepts in it too, sort of if there's two similar concepts you're not sure which one to use, so it could be a bit confusing. (Girl, Year 12).*

Another also indicated:

*In physics we have to think about those things we can't see. Like the magnetic fields and current, and you get confused when you actually have to think and imagine about things you don't actually see. (Girl, Year 13)*

The students were however, convinced that these problems were integral to the nature of physics and they appeared to be inevitable. The only option available to them was to either put in more effort if they would like to continue studying physics or stop taking physics further, the latter which many of the students sought to do. Most students indicated they would not take physics as a subject at university but might take “physics-enriched” subjects like engineering, medicine, and health sciences because of the career prospects. Some students indicated that if tertiary level physics was more enjoyable than it was at high school, then they would be interested, but they had heard that it becomes more difficult to understand at university. Of the 82 students interviewed, only five, representing six percent (6%) considered they might become physics teachers at some point in their life.

On how they liked their physics teachers to change his/her teaching styles or make physics interesting to learn, most of the students commented that the teaching was dry most of the time and made the subject boring, and hence they proposed more group activities and discussions so that they could interact with and learn from their peers. Students also wanted more practical and hands-on activities, they saw this as more fun and interactive and thereby making physics interesting to learn.

*I think more group activities and classroom discussions so that we could work off each other's strengths and weaknesses to achieve better results in the class. (Boy, Year 13)*

The students again expressed that instead of having a general physics lesson which was supposed to cater for the whole class, they would prefer to work in smaller groups, do lots of questions and be given more time to discuss physics problems between and among themselves. In their view, they spent too much time copying the teacher's notes and also indicated that they needed concepts explained more than once by the teacher.

### Discussion and Implication

The flow of people moving into physics teaching as a career needs to be addressed urgently. It seems that “the plug is out” in terms of students not seeing physics teaching as a career they aspire to. The “tap is also half on” in terms of the flow of students potentially pursuing physics further. This could be in part because there is a perceived lack of student-centred instructional approaches. In New Zealand the assessment system for physics values recall of physics content and therefore this is what teachers focus on. The use of more traditional teaching approaches for physics, i.e. a focus on content knowledge, means that students think physics is a “hard” or difficult subject and not something they want to participate in further. Some students in this study took physics because it is a requirement for application within future qualifications such as for engineering and medicine. However physics would potentially be more interesting to learn through a range of more student-centred approaches and the incorporation of different approaches such as the use of modelling, animations and simulations for problem solving (Afra et al., 2009; Akerson et al., 2007; Campbell et al., 2011; Dünser et al., 2012; Ülen & Gerlič, 2012)

As reported in many international studies, findings from this study conducted with a wide range of teachers throughout New Zealand indicated that physics classroom dialogue tends not to support constructivist epistemology or inquiry based teaching and learning which

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NZC greatly emphasizes. Student-centred instructional approaches were not common in many physics classes. In most cases, teachers decided on what happened in the classroom and students ideas and suggestions played little role in the planning of teaching and learning processes. Also, students rarely had the opportunity to strategize their own designs for experiments. Similar findings were made by (Angell et al., 2004; Hackling et al., 2001; Masika, 2011; Vosniadou, 2007) who observed that physics classroom instruction was dominated by teacher-centred approaches and chalk and talk instructions.

Teachers' inabilities to create classroom instructions centred on students thinking and ideas have its own consequences on students' interest in physics. As observed by Darling-Hammond and Baratz-Snowden (2005) and Smart and Marshall (2012) the range of information and thinking skills students may learn is largely influenced by the types of classroom practices adopted by the teacher and therefore the learning experiences they afford. Again learning is largely influenced by the way students interact in the classroom – through pedagogies involving full interaction, collective reflection and development of consensual knowledge (Conner, 2014; Darling-Hammond & Baratz-Snowden, 2005; Moraru et al., 2011; Smart & Marshall, 2012). Physics teachers therefore need to know and design instructional lessons such that students can learn from each other. More so, students in the focus group called for more group activities and discussions, and hands-on activities which will create a platform to learn from each other's strengths and weaknesses to achieve better results. This may result in students' developing positive attitude for physics and wanting to take further studies in physics at higher levels of their education.

The teachers in their own words indicated that most students could not really see physics as a life science because physics was not well taught in a way to apply it in everyday life and admitted that physics teaching had been very traditional, talk and chalk type. The finding also compliments the students' assertion that physics teaching is mostly pretty dry and boring. Teachers love for and continual usage of this traditional instructional approach may be due to their experiences at school, both as students and pre-service teachers as some of them indicated. This revelation buttresses the claim that teachers of science often teach in the way they were taught (see for example Blanton, 2003; Koballa et al., 2005; Ladachart, 2011; McDermott & Shaffer, 2000). As noted by the students, physics is naturally not an easy subject. It involves lots of concepts and mathematics which quite often scary for many students. The responsibility therefore lies on physics teachers to create an enabling atmosphere in the classroom that would make physics students lean more and develop interest for it. As Conner (2013a) pointed out, changes to teaching methods are likely to have positive impact on student learning.

The revelation that physics teachers in this study sporadically or rarely used ICT tools for physics learning was very disconcerting and could be one area for future pedagogical development with teachers, especially since professional learning was one aspect the teachers mentioned they needed. Professional learning programmes should support teachers to deepen their pedagogical content knowledge to make learning interesting and relevant. Teachers' lack of use interactive instructional approaches (Dünser et al., 2012; Ülen & Gerlič, 2012; Wieman et al., 2008) in physics classrooms on frequent and regular basis may largely be attributed to the limiting factors given by the teachers. It is possible that most of the teachers are not adequately resourced to use ICT tools in teaching physics, a situation one cannot

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blame the teachers. It can also be inferred from the findings that amidst other factors there is pressure on them to complete assessments tasks. In addition to this is the general lack of recognition for the teaching profession. For physics teachers to develop the passion for it and deliver quality teaching and learning they (teachers) should be recognised as professionals who pactively participate in professional learning. They would be motivated by better salary and incentives equivalent to their colleagues in industry. It is our wish that conditions of service and salary in particular, of physics teachers be revised and elevated to that of the counterparts in other professions. Improved status will certainly increase the numbers of teachers. Given that most of the physics students in this study did not want to become physics teachers (but rather wanted to be in highly paid jobs like Engineering), there is not sufficient "pipeline" for physics teachers in the future.

There is also reason to believe that some students are taught physics by teachers not qualified as physics teachers who for one reason or another switched to physics teaching from other subjects. It is an undeniable fact that these teachers do not have sufficient content matter knowledge which tends to disadvantage students. Students are likely to experience poor physics teaching and would not be motivated or have the passion to study physics beyond high school level.

There is also unequal access to physics education at the junior level as pointed out by both teachers and students. There seems to be more biology teachers teaching junior science in New Zealand schools which itself is structured into physics, chemistry and biology. In most cases the other science teachers put physics to the "back burner" because they may not understand it or do not have the passion for it. This has probably contributed to lower numbers choosing physics and possibly lower achievement as well. It is reasonable to surmise that the lack of subject specialists has created this situation over a number of years.

Some possible ways to increase the number of physics teachers might include partnerships between stakeholders and businesses to provide scholarships for people who have majored in physics to become teachers and for people with physics related careers who could be diverted into teaching through such incentives. Part-time pathways for initial teacher education might assist potential physics teachers to transition from the workplace. In other countries for instance USA, UK, Germany, Norway and Australia, alternative routes, other than the traditional college and university-based teacher education programmes, such Teach First has been employed to train and recruit more physics teachers. We conclude by making an appeal to the higher authorities and stakeholders of education to make a concerted effort to support and educate more physics graduates for the classroom.

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